EFFECT OF MOISTURE CONTENT ON THE DIELECTRIC PROPERTIES OF SOME SOLID INSULATING MATERIALS AT U.H.F.

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ABSTRACT. Variations of dielectric constant and power factor of ebonite and fibre with different moisture contents have been studied at frequencies of 214 Mc/s to 750 Mc/s. Result shows increases of dielectric constant with increasing moisture content. Rate of increase of power factor with increasing moisture content is much greater at lower frequencies. Loss factor, temperature coefficient of dielectric constant and power lost in the dielectrics at several frequencies for different percentages of moisture content have been calculated.

INTRODUCTION

Presence of moisture, either inside or on the surface of dielectric materials, exercises a vitally important effect on their insulating properties. The importance of moisture can be very well marked in materials which contain, either as natural constituent or as accidental contaminants, electrolytic substances which may dissolve in water to form conducting solutions. Occluded air can also influence the dielectric behaviour, particularly, when the applied voltage becomes sufficient to cause ionisation of the gas. This ionisation produces an increase in the number of conducting particles and rapid increase in the D.C. conductivity and, possibly, in the power factor with voltage. Practically all commercially available solid insulating materials contain occluded air and are sensitive in greater or less degree to atmospheric moisture. It has, therefore, been thought worthwhile to study the effect of moisture content on the dielectric properties at u. h. f. for insulating materials like ebonite and fibre which are easily available in India.

EXPERIMENTAL

Experimental technique involves the determination of maximum wave shift with and without the materials placed along a Lecher wire system between the source and shorting bridge. For the determination of power factor, a knowledge of the width of resonance curve at half power points is necessary in addition to that of maximum shift. The following relation (King, 1937) has been utilised for calculating dielectric constant ϵ

$$\tan \frac{\pi}{\lambda}(\text{max. shift} + s_1) = \sqrt{\epsilon}.\tan \frac{\pi s_1 \sqrt{\epsilon}}{\lambda}$$

where s_1 = thickness of the material in cms.

λ = wavelength of excitation in cms.

The power factor $\tan\delta$ has been determined from the following relation (Chatterjee, 1948) :—

$$\tan\delta = 1 - \frac{\tan\frac{2\pi}{\lambda}\left(l_0 - l_r - \frac{l_1 - l_2}{2}\right)}{\tan\frac{2\pi}{\lambda}(l_0 - l_r)}$$

where $l_0 - l_r$ = wave shift in cms.

$\frac{l_1 - l_2}{2}$ = half width in cms. of the resonance curve at half power points.

Experimental detail has been published elsewhere (Chatterjee and Rajeswari, 1948). In order to determine the effect of moisture the samples were soaked in water for 24 hours. Percentage of moisture content is determined from the difference in the weights of the sample in the dry and wet condition. The sample is then subjected to successive stages of heating and at each stage values of ϵ and $\tan\delta$ have been determined. The sample is weighed before and after each experiment to find the effect of absorption of moisture from the atmosphere during the experiment. The average weights have been taken. Results of experiment for ebonite and fibre for some of the frequencies are given in Figs 1 to 4.

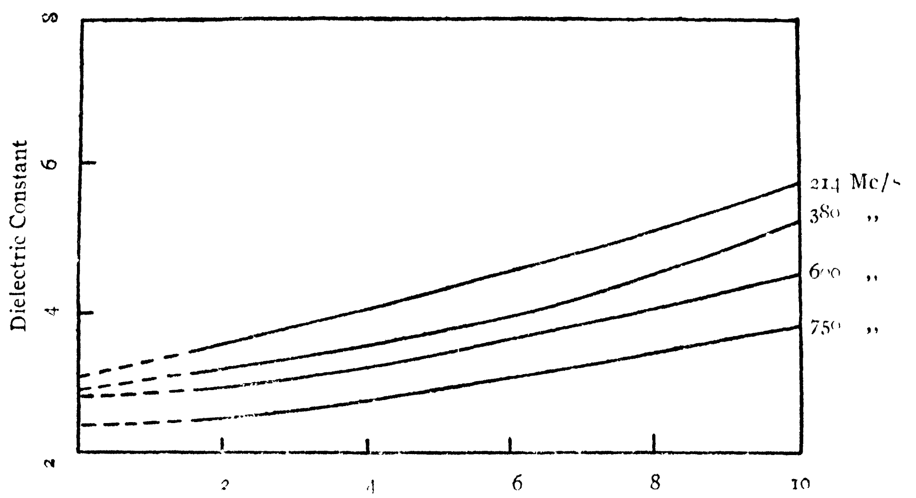

FIG. 1

Variation of dielectric constant of ebonite with moisture

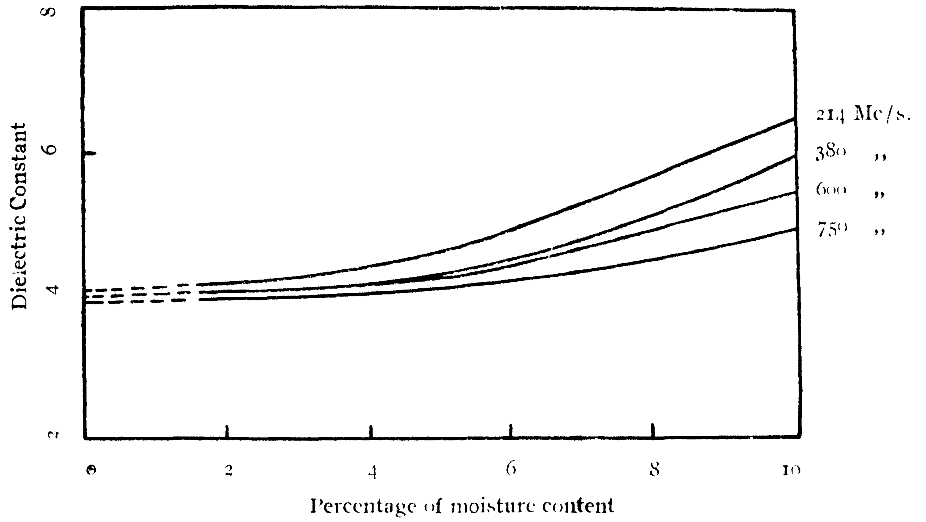

FIG. 2

Variation of dielectric constant of fibre with moisture

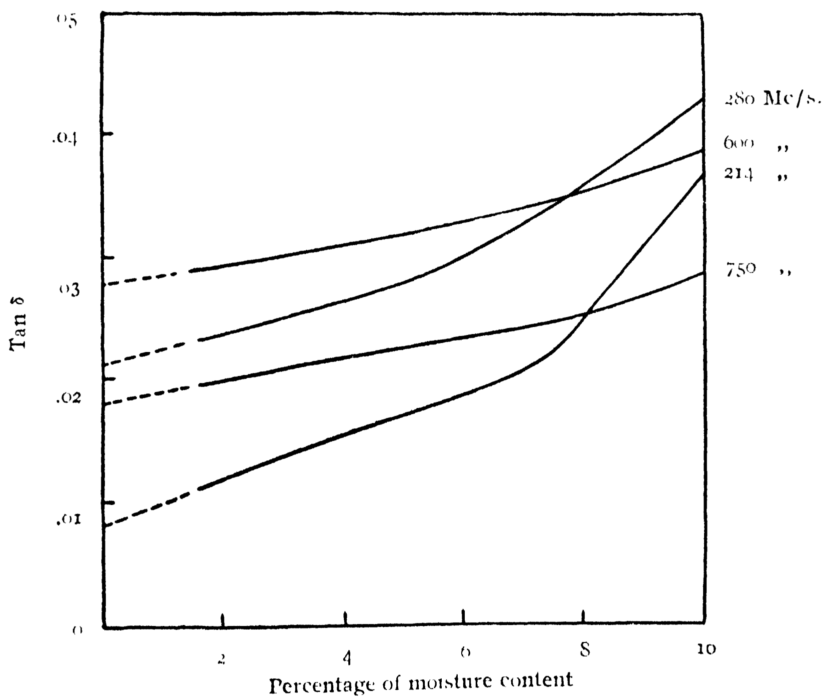

FIG. 3

Variation of tan δ of ebonite with moisture content

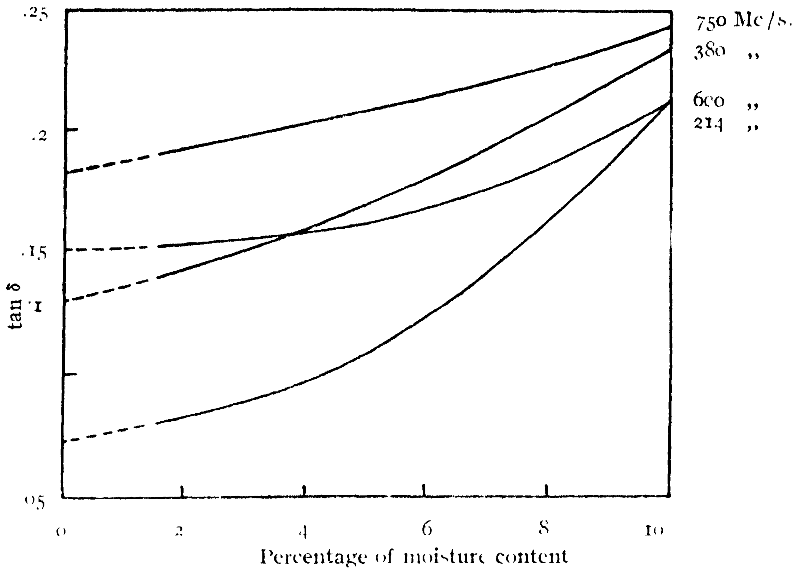

FIG. 4

Variation of tan δ of fibre with moisture content

DISCUSSION

It is observed from Figs. 1 and 2 that the dielectric constant increases with increasing moisture content. This is expected as the permittivity of water is high. The increase of ϵ with percentage of moisture content is much slower at higher frequency. Power factor increases sharply (Figs. 3 and 4) at the lower frequency end with increasing moisture content, but at the high frequency the increase is rather slow. Increase of power factor with moisture may be explained due to low resistivity of the material at high moisture content.

Values of loss factor ϵ. tan δ for both the materials at four frequencies and for different percentage of moisture content have been computed (Table I) from Figs. 1 to 4.

TABLE I

Material : Ebonite

Frequency in Mc/s.	ϵ. tan δ at different % moisture content				
	1.6	3.2	5.3	7.6	10.0
214	.037	.053	.071	.106	.202
380	.071	.085	.106	.143	.214
600	.081	.090	.106	.129	.167
750	.046	.055	.064	.077	.104

TABLE I (*contd.*)

Material: Fibre

Frequency in Mc/s	$\epsilon' \tan\delta$ at different % moisture content				
	1.6	3.2	5.3	7.6	10
214	.358	.378	.506	.81	1.32
380	.56	.615	.751	.98	1.55
600	.60	.656	[illegible]	.846	1.11
750	.741	.8	.86	.95	1.15

The power loss in watts (Table II) at different frequencies for varying degrees of moisture content have been calculated from Table I and following relation (Hoch, 1952) —

Power loss in watts per cubic inch

$$= 2\pi f E^2 \epsilon' \tan\delta \times 0.2244 \times 10^{-1}$$

where,

f = frequency in c. p. s.

E = voltage gradient in dielectric in r. m. s. volts per inch = 20 volts per inch

TABLE II

Material: Ebonite

Frequency in Mc/s	Power loss at different % moisture content $\times 10^{5}$				
	1.6	3.2	5.3	7.6	10
214	4.5	6.4	8.6	12.8	24.4
380	15.2	18.2	2[illegible]	30.6	15.8
[illegible]	8.4	3[illegible].4	55.8	15	56.4
750	19.8	23.3	7.1	32.[illegible]	110

Material: Fibre

214	39.7	45.7	61.2	98.0	159.7
380	119.8	131.6	156.4	209.7	284.6
600	202.8	221.7	227.1	285.9	375.2
750	313.4	338.4	363.8	401.9	486.5

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